

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 357 260 A2

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:

29.10.2003 Bulletin 2003/44

(51) Int Cl.7: F01L 1/34

(21) Application number: 03251467.1

(22) Date of filing: 11.03.2003

(84) Designated Contracting States:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR  
HU IE IT LI LU MC NL PT RO SE SI SK TR

Designated Extension States:

AL LT LV MK

(30) Priority: 22.04.2002 US 374331 P

14.11.2002 US 294277

(71) Applicant: BorgWarner Inc.

Auburn Hills, MI 48326-1782 (US)

(72) Inventor: Lewis, Jeffrey

Freeville, New York 13068 (US)

(74) Representative: Lerwill, John et al

A.A. Thornton & Co.

235 High Holborn

London, WC1V 7LE (GB)

### (54) VCT lock pin having a tortuous path providing a hydraulic delay

(57) A variable cam timing phaser having a tortuous path (14) from the supply of pressurized oil to the tapered recess (19) into which the locking pin (10) fits, that introduces a delay between when the engine starts and when the locking pin moves to an unlocked position. The tortuous path (14) restricts fluid flow, preventing the locking pin (10) from unlocking during engine start-up

with the initial oil pressurization, prior to the variable cam timing phaser having sufficient oil to operate. The delay ensures that the chambers of the variable cam timing phaser have time to fill with operating fluid before the phaser is unlocked.

**Description****FIELD OF THE INVENTION**

**[0001]** The invention is related to a hydraulic control system for controlling the operation of a variable cam-shaft timing (VCT) system. More specifically, the present invention relates to a control system, which utilizes a tortuous or restricted path to delay the release of the locking pin.

**DESCRIPTION OF RELATED ART**

**[0002]** Internal combustion engines have employed various mechanisms to vary the angle between the cam-shaft and the crankshaft for improved engine performance or reduced emissions. The majority of these variable camshaft timing (VCT) mechanisms use one or more "vane phasers" on the engine camshaft (or camshafts, in a multiple-camshaft engine). In most cases, the phasers have a rotor with one or more vanes, mounted to the end of the camshaft, surrounded by a housing with the vane chambers into which the vanes fit. It is possible to have the vanes mounted to the rotor, and the chambers in the stator, as well. The housing's outer circumference forms the sprocket, pulley or gear accepting drive, usually from the camshaft (typically a chain, belt or gears). The phaser operates using engine oil as the working fluid, introduced into the oil chambers on either side of vanes, so as to rotate the camshaft angularly relative to the drive from the crankshaft.

**[0003]** Since the phasers cannot be perfectly sealed they are subject to oil loss through leakage. During normal engine operation, the oil pressure and flow generated by the engine oil pump is generally sufficient to keep the phaser full of oil and fully functional. However, when the engine is shut down, the oil can leak from the VCT mechanism. During engine start conditions, before the engine oil pump generates oil pressure, the lack of controlling oil pressure may allow the phaser to oscillate excessively due to lack of oil, producing noise and possibly damaging the mechanism. Additionally, it is desirable to have the phaser locked in a particular position while the engine is attempting to start.

**[0004]** One solution employed in prior art phasers is to introduce a locking pin that will lock the phaser in a specific phase angle position relative to the crankshaft when insufficient oil exists in the chambers. These locking pins are typically spring loaded to engage and are released using engine oil pressure. Therefore, when the engine is shut down and engine oil pressure reaches some predetermined low value the spring-loaded pin will engage and lock the phaser. During engine start, the pin remains engaged until the engine oil pump generates enough pressure to release the pin.

**[0005]** A second example of prior art locking pins is U.S. Patent No. 5,836,275, which discloses a locking pin having a "canceling means" to prevent retraction of

the locking pin until the chambers are filled with oil. The "canceling means" being a small hole at the bottom end of a hole located in the housing that extends inward in the radial direction.

**5 [0006]** Another example is U.S. Patent No. 5,901,674, which shows a lock pin having a separate unlock line and valve. The locking pin restricts the rotation of the inner rotor and the outer rotor until after the engine has been started. During this time period, a sufficient oil supply is being built up in the advancing and delaying chamber to unlock the locking pin.

**[0007]** U.S. Patent No. 5,927,239 discloses a locking pin with a flow restrictor upstream of a coupling member. The flow restrictor being a steel ring which is secured to the housing, having an inner ring surrounding a slide ring. The gap remaining between the inner circumference of the steel ring and the slide ring allows a hydraulic medium to travel through. Due to this restriction, a small delay is introduced in releasing the locking pin and is specifically viewed as a disadvantage by the inventors of U.S. Patent No. 5,927,239. The disadvantage of the delay is considered to be offset by the elimination of the rattling noises that emanate from the locking piston.

**[0008]** U.S. Patent No. 5,941,203 shows a lock pin 25 that is shaped to allow the phaser to rotate faster as the pin retracts. The shape of the locking pin consisting a head portion that is curved or spherical and a skirted portion. The head portion fits into a hole in the internal rotor to regulate the relative rotations of the internal and external rotor. As more working oil is fed into the hole, the locking pin is pushed out until it no longer regulates the rotations of the internal and external rotor.

**[0009]** Another example is U.S. Patent No. 5,979,380, which discloses a vane phaser with a locking pin. An application of pressure retracts the pin. The locking pin mechanism is disposed between the rotor and the housing member, including a receiving hole, formed on the outer circumferential portion of the rotor, a canceling hole, which is formed on the inner circumferential portion of the housing member, so as to be able to align with the receiving hole, and a stepped locking pin which is slidably fitted into the canceling hole. When pressure of the fluid discharged is high enough, the changeover valve is changed to the first position, the pressurized fluid is supplied to the first chamber and the receiving hole simultaneously, and the locking pin is then pushed out the hole to allow rotation to occur.

**[0010]** U.S. Patent No. 6,006,708 discloses a lock pin retraction that takes place due to oil passages in both 50 the advance and retard chambers. The retraction is delayed by the ECU during engine startup to avoid problems associated with low oil pressure.

**[0011]** U.S. Patent No. 6,006,709 shows a lock pin that locks a phaser under low oil conditions. The lock 55 pin retraction is delayed until there is sufficient oil in the advance chamber to avoid a rattling on startup.

**[0012]** Another example is U.S. Patent No. 6,024,061 discloses lock pin that is removed when full retard pres-

sure is available to hold the phaser in a retarded condition before operation. This is achieved by having the ECU execute a delay on startup before applying retard pressure to the phaser so as to allow oil pressure to build up.

**[0013]** U.S. Patent No. 6,035,819 discloses a phaser that is switched to the most advanced position as the engine stalls and then moves to a locked position as the engine starts. Without adequate pressure, the locking pin stays locked and holds the phaser in the middle of the pressure chamber. The phaser is unlocked after the engine is started. A slight delay is experienced since the vane is in the middle of the pressure chamber.

**[0014]** Lastly, U.S. Patent No. 6,105,543 shows a spherical end to a locking pin to facilitate withdrawal as pressure is built up.

**[0015]** A drawback of these current locking pins is that they unlock with the initial oil pressurization, prior to the phaser having sufficient oil to operate.

**[0016]** Therefore, a locking mechanism is needed that causes the locking pin to be released after a delay between engine startup and when the locking pin is disengaged from the rotor.

#### SUMMARY OF THE INVENTION

**[0017]** The invention comprises a variable cam timing phaser having a tortuous path from the supply of pressurized oil to the tapered recess into which the locking pin fits, that introduces a delay between when the engine starts and when the locking pin moves to an unlocked position. The tortuous path restricts fluid flow, preventing the locking pin from unlocking during engine start-up with the initial oil pressurization, prior to the variable cam timing phaser having sufficient oil to operate. The delay ensures that the chambers of the variable cam timing phaser have time to fill with operating fluid before the phaser is unlocked.

#### BRIEF DESCRIPTION OF THE DRAWING

**[0018]**

Fig. 1 shows a front view of a VCT phaser incorporating the invention.

Fig. 2a & 2b shows engaged and disengaged positions of the present invention respectively, in detail from within box 2 in figure 1.

#### DETAILED DESCRIPTION OF THE INVENTION

**[0019]** Referring to figure 1, a vane-type VCT phaser comprises a housing (1), the outside of which has sprocket teeth (8) which mesh with and are driven by timing chain (9). Inside the housing (1) are fluid chambers (6) and (7). Coaxially within the housing (1), free to rotate relative to the housing, is a rotor (2) with vanes

(5) which fit between the chambers (6) and (7), and a central control valve (4) which routes pressurized oil via passages (12) and (13) to chambers (6) and (7), respectively. Pressurized oil introduced by valve (4) into passages (12) will push vanes (5) counterclockwise relative to the housing (1), forcing oil out of chambers (6) into passages (13) and into valve (4).

**[0020]** It will be recognized by one skilled in the art that this description is common to vane phasers in general, and the specific arrangement of vanes, chambers, passages and valves shown in figure 1 may be varied within the teachings of the invention. For example, the number of vanes and their location can be changed - some phasers have only a single vane, others as many as a dozen, and the vanes might be located on the housing and reciprocate within chambers on the rotor. The housing might be driven by a chain or belt or gears, and the outside of the housing might be sprocket teeth as shown, or a pulley for a belt, or gears.

**[0021]** Referring to Figure 1 and the detail of figure 2a, in the phaser of the invention, a locking pin (10) slides in a bore (17) in the housing (1), and is pressed by a spring (21) into a recess (19) in the rotor (2) to lock the rotor (2) and housing (1) into a fixed rotational position. A vent (11) allows any oil, which might leak past the piston (10) to be discharged. A bushing (16) may be provided in the bore, surrounding at least the inner end (20) of the locking pin, to provide a better seal.

**[0022]** A tortuous fluid passage (14) feeds pressurized oil from a supply of pressurized oil (15) into the recess (19). The tortuous path (14) may be a worm trail, a small hole, or a restriction present anywhere along the path from the supply of pressurized oil to the locking pin. Due to the tortuous path (14) in which the oil travels before it arrives at the recess (19), sufficient pressure to unlock the locking pin (10) is not available until the operating chambers of the VCT are mostly filled with oil.

**[0023]** Thus, at engine start-up, oil has to travel the tortuous fluid passage, adding time delay before arriving at the recess, which thus cannot push the locking pin back against the force of the spring until the supply oil pressure has risen to a level in which there is sufficient oil in the passages to fully fill the chambers of the phaser.

**[0024]** When the engine is shut down, the pressure in the recess and the passage drops below the required pressure to hold the pin in the bore against the force of the spring, and the locking pin moves toward the rotor. When the pin and the recess come into alignment the pin drops into the recess locking the rotor and housing.

**[0025]** Accordingly, it is to be understood that the embodiments of the invention herein described are merely illustrative of the application of the principles of the invention. Reference herein to details of the illustrated embodiments is not intended to limit the scope of the claims, which themselves recite those features regarded as essential to the invention.

**Claims**

1. A variable camshaft timing phaser for an internal combustion engine having at least one camshaft comprising:
  - a) a housing having an outer circumference for accepting drive force;
  - b) a rotor for connection to a camshaft, coaxially located within the housing, capable of rotation to shift the relative angular position of the housing and the rotor, having a tapered recess in an outer circumference;
  - c) a locking pin slidably located in a radial bore in the housing adjacent the rotor, comprising a body having a diameter adapted to a fluid-tight fit in the radial bore, and an inner end toward the rotor with a tapered portion adapted to fit in the tapered recess, the locking pin being radially moveable in the bore from a locked position in which the tapered end fits into the tapered recess, locking the relative angular position of the housing and the rotor, to an unlocked position, in which the tapered end does not engage the rotor;
  - d) a spring located in the radial bore opposite the inner end of the locking pin, urging the locking pin radially inward toward the locked position; and
  - e) a tortuous fluid passage coupling the tapered recess to a supply of pressurized oil, such that a time delay is introduced in moving the tapered end of the locking pin from the tapered recess in the rotor..
2. The variable camshaft timing phaser of claim 1, further comprising a bushing in the bore surrounding at least the inner end of the locking pin.
3. The variable camshaft timing phaser of claim 1 or 2, wherein the tortuous fluid passage is a worm trail.

50

55

Fig. 1

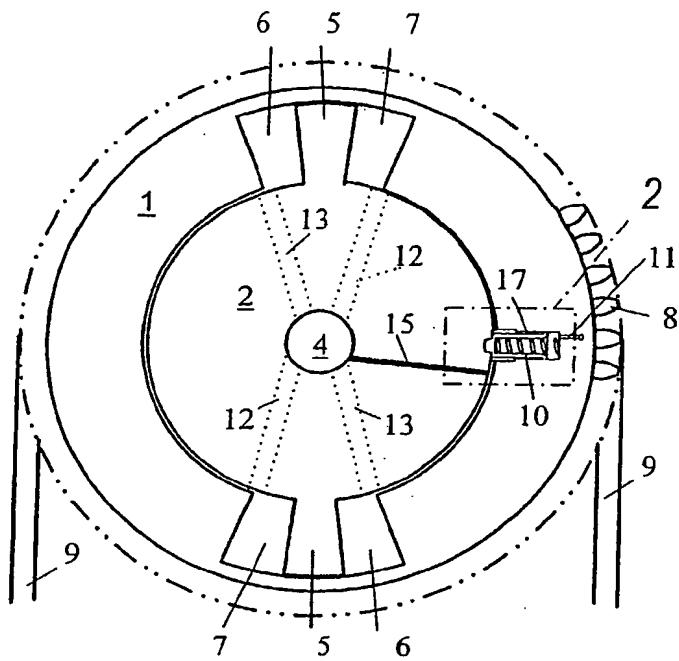


Fig. 2a

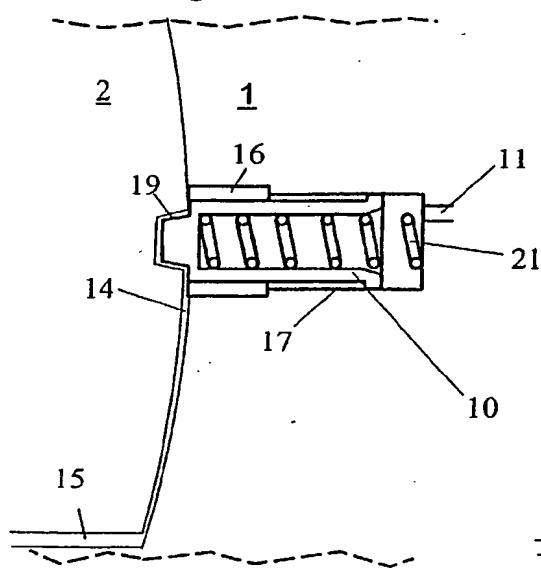
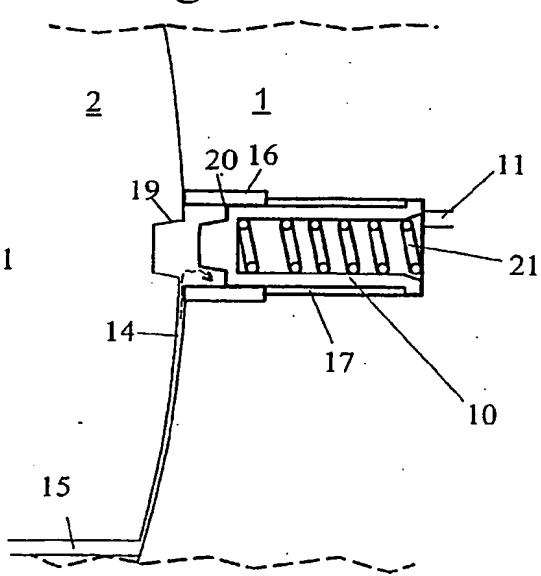


Fig. 2b



(19)



Europäisches Patentamt  
European Patent Office  
Office européen des brevets

(11)



EP 1 357 260 A3

(12)

## EUROPEAN PATENT APPLICATION

(88) Date of publication A3:  
17.12.2003 Bulletin 2003/51

(51) Int Cl.7: F01L 1/34, F01L 1/344

(43) Date of publication A2:  
29.10.2003 Bulletin 2003/44

(21) Application number: 03251467.1

(22) Date of filing: 11.03.2003

(84) Designated Contracting States:  
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR  
HU IE IT LI LU MC NL PT RO SE SI SK TR  
Designated Extension States:  
AL LT LV MK

(30) Priority: 22.04.2002 US 374331 P  
14.11.2002 US 294277

(71) Applicant: BorgWarner Inc.  
Auburn Hills, MI 48326-1782 (US)

(72) Inventor: Lewis, Jeffrey  
Freeville, New York 13068 (US)

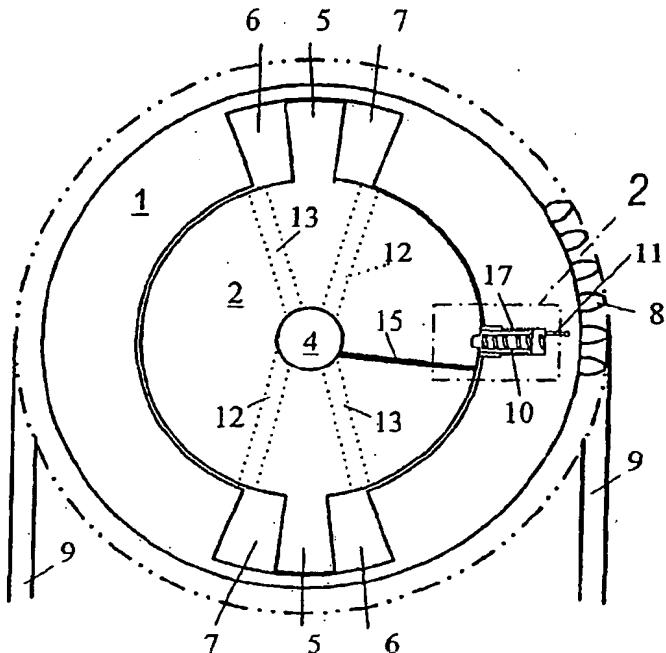
(74) Representative: Lerwill, John et al  
A.A. Thornton & Co.  
235 High Holborn  
London, WC1V 7LE (GB)

### (54) VCT lock pin having a tortuous path providing a hydraulic delay

(57) A variable cam timing phaser having a tortuous path (14) from the supply of pressurized oil to the tapered recess (19) into which the locking pin (10) fits, that introduces a delay between when the engine starts and when the locking pin moves to an unlocked position. The tortuous path (14) restricts fluid flow, preventing the

locking pin (10) from unlocking during engine start-up with the initial oil pressurization, prior to the variable cam timing phaser having sufficient oil to operate. The delay ensures that the chambers of the variable cam timing phaser have time to fill with operating fluid before the phaser is unlocked.

Fig. 1



EP 1 357 260 A3



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number

EP 03 25 1467

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Y	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 13, 30 November 1999 (1999-11-30) & JP 11 229830 A (MIKUNI CORP), 24 August 1999 (1999-08-24) * abstract * * figures 2,4 *	1,2	F01L1/34 F01L1/344
A	---	3	
Y	US 6 006 709 A (USHIDA MASAYASU) 28 December 1999 (1999-12-28) * column 1, line 14-22 * * figure 17 *	1,2	
A	---		
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 25, 12 April 2001 (2001-04-12) & JP 2001 221016 A (MIKUNI CORP), 17 August 2001 (2001-08-17) * abstract * * figures 2-9,11B *	1,3	
A	---		
A	PATENT ABSTRACTS OF JAPAN vol. 2002, no. 05, 3 May 2002 (2002-05-03) & JP 2002 004820 A (MITSUBISHI ELECTRIC CORP), 9 January 2002 (2002-01-09) * abstract * * figures 2,4-13 *	1,3	TECHNICAL FIELDS SEARCHED (Int.Cl.7) F01L B60R
A	---		
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 05, 14 September 2000 (2000-09-14) & JP 2000 045725 A (AISIN SEIKI CO LTD), 15 February 2000 (2000-02-15) * abstract * * figures 2-5 *	1-3	
	---		
		-/-	
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		28 October 2003	Paquay, J
CATEGORY OF CITED DOCUMENTS			
X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document			
T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons & member of the same patent family, corresponding document			



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 0 751 048 A (MORTON INT INC) 2 January 1997 (1997-01-02) * column 1, line 7-11 * * column 10, line 7-16 * * column 12, line 12-23 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	28 October 2003	Paquay, J	
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone	T : theory or principle underlying the invention		
Y : particularly relevant if combined with another document of the same category	E : earlier patent document, but published on, or after the filing date		
A : technological background	D : document cited in the application		
O : non-written disclosure	L : document cited for other reasons		
P : intermediate document	& : member of the same patent family, corresponding document		

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 25 1467

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

28-10-2003

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
JP 11229830	A	24-08-1999	NONE		
US 6006709	A	28-12-1999	JP JP JP US US DE GB GB GB JP JP JP JP JP JP JP JP KR US US	3075337 B2 9060507 A 9148115 A 5960757 A 6155221 A 19623818 A1 2302391 A ,B 2329951 A ,B 2329952 A ,B 3033581 B2 2000002103 A 3033582 B2 2000002104 A 2000002105 A 3146956 B2 9060508 A 233618 B1 6199524 B1 5823152 A	14-08-2000 04-03-1997 06-06-1997 05-10-1999 05-12-2000 19-12-1996 15-01-1997 07-04-1999 07-04-1999 17-04-2000 07-01-2000 17-04-2000 07-01-2000 07-01-2000 19-03-2001 04-03-1997 01-12-1999 13-03-2001 20-10-1998
JP 2001221016	A	17-08-2001	NONE		
JP 2002004820	A	09-01-2002	NONE		
JP 2000045725	A	15-02-2000	NONE		
EP 0751048	A	02-01-1997	US EP	5582427 A 0751048 A2	10-12-1996 02-01-1997

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82